Development of a Superconducting Magnet System for a Helicon Plasma Thruster

John J. Vitucci and Raymond J. Sedwick
University of Maryland
Department of Aerospace Engineering
3179 Glenn L. Martin Hall, College Park, MD 20740
301-405-8562 | jvitucci@umd.edu

Helicon plasma sources conventionally require an externally applied, axial magnetic field that supports helicon wave propagation, implemented through the use of an electromagnet or a permanent magnet. While there is little to suggest the strength of the axial magnetic field directly contributes to ion acceleration, there has been evidence demonstrating that its geometry is of greater influence. For example, a diverging magnet field supports the development of a plasma sheath at the exit plane of the thruster, resulting in the acceleration of the ions without the need of either accelerating grids or an external neutralizing cathode. In addition to supporting the primary acceleration mechanism, the magnetic field structure is hypothesized to reduce the power loss to the plasma sheath at the plasma boundary. One such mechanism to improve plasma confinement is a magnetic mirror. It has been hypothesized that implementing a converging magnetic field upstream can drastically reduce the power loss at the upstream plasma sheath, thus improving the power efficiency of the helicon thruster. Incorporating this hypothesis now adds two constraints on the magnetic field geometry. First, it must maintain axial uniformity downstream and within the confines of the helical antenna in order to support propagation of the helicon wave. Second, upstream of the helical antenna, the magnetic field lines must converge in a magnetic mirror configuration to improve plasma confinement at the upstream boundary. To achieve such a structure, permanent magnets, solenoids, and type II superconductors are utilized to tailor the magnet field geometry to a desired topology. This research is intended to address the design of both a superconducting magnet system for helicon thruster applications, and also a closed-loop thermal management system to maintain cryogenic temperatures.